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VIRGINIA TRUCK EXPERIMENT STATION

DIGESTIBILITY OF SOME VEGETABLE FATS.

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INTRODUCTION.

Studies of the digestibility of some common animal fats, including lard, beef fat, mutton fat, and butter, have been reported in a previous paper[1] of this series. The results of these experiments showed that all the animal fats investigated were satisfactorily digested and are suitable for use in quantity as food.

The available supply of animal fats, however, is now little if any in excess of the demand, and it is likely that the supply of such fats for culinary purposes in the future will be even less adequate than at the present time. It is probable, therefore, that in the future greater reliance must be placed on the vegetable fats to supplement the available animal-fat supply. The experiments reported in this bulletin, showing the thoroughness of digestion of certain vegetable oils and indicating in a general way their suitability for food, have an important bearing on this question. The fats studied included olive oil, cottonseed oil, peanut oil, coconut oil, sesame oil, and cocoa butter.

EXPERIMENTAL METHODS.

The digestion experiments with the vegetable fats were conducted by the same methods that were employed in the study of the animal fats, and accordingly the results are directly comparable. A basal ration (supplying a minimum of fat) composed of wheat biscuits, oranges, sugar, and tea, or coffee if desired, was supplemented by a blancmange or cornstarch pudding, in which was incorporated the vegetable fat under consideration.

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[1] U. S. Dept. Agr. Bul. 310 (1915).

NOTE.—This bulletin records studies of the digestibility of olive oil, cottonseed oil, peanut oil, coconut oil, sesame oil, and cocoa butter, and is primarily of interest to students and investigators of food problems.

The test periods were of three days' or nine meals' duration, to agree with the experimental conditions under which the animal fats were studied, and the following four days formed a rest period in which the subjects furnished their own meals, which differed in no special way from an ordinary mixed diet.

Normal young men in good health and moderately active, all of whom were medical or dental students, were the subjects of the digestion experiments. The prescribed routine involved regularity, especially with respect to the time for eating, but the subjects were permitted to exercise in their customary ways and as required in the performance of their daily work. In most cases the subjects had had previous experience in similar experiments, and all of them proved to be careful and trustworthy assistants.

Weighings were made of the net amounts of food eaten and feces excreted, and samples of both food and feces were analyzed to determine the percentages of protein, fat, and carbohydrate which were actually digested.

The experimental method followed has been reported in a previous bulletin of this series,[1] the analytical methods being those which are approved by the Association of Official Agricultural Chemists.[2]

DIGESTION EXPERIMENTS.

OLIVE OIL.

Although olive oil has been known from earliest times as a food product, exact information regarding the proportion assimilated by the body is comparatively limited, its food value having been generally discussed with respect to its theoretical energy value, its quality, and culinary and table uses. As regards earlier work, a five-day experiment with a healthy man was conducted by Bertarelli,[3] who tested the digestibility of a mixture of olive and colza oils in a basal ration of white bread and meat; the fat was 95.8 per cent digested. Moore [4] has reported a number of animal feeding experiments in which he found that olive oil was assimilated to the extent of from 96.7 to 98.7 per cent. In a comparative series of tests he noticed that uncooked oils in the food of guinea pigs were somewhat less thoroughly available than was the case when the oil was cooked with the food. In general all of the vegetable fats studied were digested to practically the same extent.

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[1] U. S. Dept. Agr. Bul. 310 (1915).

[2] U. S. Dept. Agr., Bur. Chem. Bul. 107 (1912), rev. ed.

[3] Riv. Ig. e Sanit. Pub., 9 (1898), Nos. 14, pp. 538–545; 15, pp. 570–579.

[4] Arkansas Sta. Bul. 78 (1903), pp. 33–41.

Arnschink[1] reports an experiment of four days' duration with a dog of 8 kilograms body weight. Fifty grams of olive oil was consumed daily and 97.77 per cent digested.

Olive oil has been studied from another viewpoint, namely, its ability, as compared with certain animal fats such as butter and cod liver oil, to maintain growth. Work along these lines has been reported by Osborne and Mendel[2] and McCollum and Davis,[3] who concluded that olive oil was not capable of stimulating or maintaining growth.

In experiments here reported five subjects took part in the 11 digestion experiments, the results of which are given in the following tables:

Data of digestion experiments with olive oil in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 151, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing olive oil	1,579.0	734.7	26.7	192.6	618.4	6.6
Wheat biscuit	633.0	57.0	67.1	9.5	489.3	10.1
Fruit	803.0	697.8	6.4	1.6	93.2	4.0
Sugar	191.0	....	....	....	191.0	....
Total food consumed	3,206.0	1,489.5	100.2	203.7	1,391.9	20.7
Feces	114.5	....	30.6	10.0	65.4	8.5
Amount utilized	....	....	69.6	193.7	1,326.5	12.2
Per cent utilized	....	....	69.5	95.1	95.3	58.9
Experiment No. 153, subject R. L. S.:						
Blancmange containing olive oil	1,587.0	738.4	26.8	193.6	621.6	6.6
Wheat biscuit	417.0	37.5	44.2	6.3	322.3	6.7
Fruit	810.0	703.9	6.5	1.6	94.0	4.0
Sugar	91.0	....	....	....	91.0	....
Total food consumed	2,905.0	1,479.8	77.5	201.5	1,128.9	17.3
Feces	102.5	....	31.4	17.2	44.1	9.8
Amount utilized	....	....	46.1	184.3	1,084.8	7.5
Per cent utilized	....	....	59.5	91.5	96.1	43.4
Experiment No. 154, subject R. F. T.:						
Blancmange containing olive oil	1,865.0	867.8	31.5	227.5	730.4	7.8
Wheat biscuit	46.0	4.1	4.9	.7	35.6	.7
Fruit	1,283.0	1,114.9	10.3	2.6	148.8	6.4
Sugar	132.0	....	....	....	132.0	....
Total food consumed	3,326.0	1,986.8	46.7	230.8	1,046.8	14.9
Feces	69.5	....	16.4	14.6	32.1	6.4
Amount utilized	....	....	30.3	216.2	1,014.7	8.5
Per cent utilized	....	....	64.9	93.7	96.9	57.0
Experiment No. 183, subject D. G. G.:						
Blancmange containing olive oil	1,127.0	494.0	21.1	138.8	465.1	8.0
Wheat biscuit	561.0	50.5	59.5	8.4	433.6	9.0
Fruit	775.0	673.5	6.2	1.5	89.9	3.9
Sugar	209.0	....	....	....	209.0	....
Total food consumed	2,672.0	1,218.0	86.8	148.7	1,197.6	20.9
Feces	69.0	....	21.4	7.5	34.2	5.9
Amount utilized	....	....	65.4	141.2	1,163.4	15.0
Per cent utilized	....	....	75.3	95.0	97.1	71.8

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[1] Ztschr. Biol., 26 (1890), No. 4, pp. 444, 445.

[2] Jour. Biol. Chem., 16 (1913), No. 3, pp. 423–437.

[3] Idem, 15 (1913), No. 1, pp. 167–175; 19 (1914), No. 2, pp. 245–250; 20 (1915), No. 4, pp. 641–658; 21 (1915), No. 1, pp. 179–182. Wisconsin Sta. Bul. 240 (1914), pp. 33, 34.

Data of digestion experiments with olive oil in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 184, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing olive oil	1,827.0	800.8	34.1	225.1	754.0	13.0
Wheat biscuit	314.0	28.3	33.3	4.7	242.7	5.0
Fruit	1,347.0	1,170.5	10.8	2.7	156.3	6.7
Sugar	122.0	....	....	....	122.0	....
Total food consumed	3,610.0	1,999.6	78.2	232.5	1,275.0	24.7
Feces	64.0	....	20.3	10.9	27.2	5.6
Amount utilized	....	....	57.9	221.6	1,247.8	19.1
Per cent utilized	....	....	74.0	95.3	97.9	77.3
Experiment No. 185, subject O. E. S.:						
Blancmange containing olive oil	1,958.0	858.2	36.6	241.2	808.1	13.9
Wheat biscuit	153.0	13.8	16.2	2.3	118.3	2.4
Fruit	1,568.0	1,362.6	12.6	3.1	181.9	7.8
Sugar	188.0	....	....	....	188.0	....
Total food consumed	3,867.0	2,234.6	65.4	246.6	1,296.3	24.1
Feces	42.0	....	12.6	5.1	20.5	3.8
Amount utilized	....	....	52.8	241.5	1,275.8	20.3
Per cent utilized	....	....	80.7	97.9	98.4	84.2
Experiment No. 186, subject R. F. T.:						
Blancmange containing olive oil	1,322.0	579.4	24.7	162.9	545.6	9.4
Wheat biscuit	91.0	8.2	9.6	1.4	70.3	1.5
Fruit	1,485.0	1,290.5	11.9	3.0	172.2	7.4
Sugar	183.0	....	....	....	183.0	....
Total food consumed	3,081.0	1,878.1	46.2	167.3	971.1	18.3
Feces	70.0	....	17.5	10.9	33.6	8.0
Amount utilized	....	....	28.7	156.4	937.5	10.3
Per cent utilized	....	....	62.1	93.5	96.5	56.3
Experiment No. 243, subject D. G. G.:						
Blancmange containing olive oil	2,321.0	985.0	43.6	266.5	1,014.3	11.6
Wheat biscuit	500.0	45.0	53.0	7.5	386.5	8.0
Fruit	1,202.0	1,044.6	9.6	2.4	139.4	6.0
Sugar	120.0	....	....	....	120.0	....
Total food consumed	4,143.0	2,074.6	106.2	276.4	1,660.2	25.6
Feces	131.0	....	37.3	12.7	71.5	9.5
Amount utilized	....	....	68.9	263.7	1,588.7	16.1
Per cent utilized	....	....	64.9	95.4	95.7	62.9
Experiment No. 244, subject R. L. S.:						
Blancmange containing olive oil	2,143.0	909.5	40.3	246.0	936.5	10.7
Wheat biscuit	437.0	39.3	46.3	6.6	337.8	7.0
Fruit	546.0	474.5	4.4	1.1	63.3	2.7
Sugar	85.0	....	....	....	85.0	....
Total food consumed	3,211.0	1,423.3	91.0	253.7	1,422.6	20.4
Feces	84.0	....	24.7	11.2	41.8	6.3
Amount utilized	....	....	66.3	242.5	1,380.8	14.1
Per cent utilized	....	....	72.9	95.6	97.1	69.1
Experiment No. 245, subject O. E. S.:						
Blancmange containing olive oil	2,690.0	1,141.6	50.6	308.8	1,175.6	13.4
Wheat biscuit	497.0	44.7	52.7	7.5	384.2	7.9
Fruit	1,228.0	1,067.1	9.8	2.5	142.5	6.1
Sugar	177.0	....	....	....	177.0	....
Total food consumed	4,592.0	2,253.4	113.1	318.8	1,879.3	27.4
Feces	126.0	....	33.4	17.8	66.7	8.1
Amount utilized	....	....	79.7	301.0	1,812.6	19.3
Per cent utilized	....	....	70.5	94.4	96.5	70.4
Average food consumed per subject per day	1,153.8	601.3	27.0	76.0	442.3	7.2

Summary of digestion experiments with olive oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
151	D. G. G	69.5	95.1	95.3	58.9
153	R. L. S	59.5	91.5	96.1	43.4
154	R. F. T	64.9	93.7	96.9	57.0
183	D. G. G	75.3	95.0	97.1	71.8
184	R. L. S	74.0	95.3	97.9	77.3
185	O. E. S	80.7	97.9	98.4	84.2
186	R. F. T	62.1	93.5	96.5	56.3
243	D. G. G	64.9	95.4	95.7	62.9
244	R. L. S	72.9	95.6	97.1	69.1
245	O. E. S	70.5	94.4	96.5	70.4
	Average	69.4	94.7	96.8	65.1

The average coefficient of digestibility of all the fat eaten during these tests was 94.7. As the ether extract of the feces, however, is known to contain metabolic products, a correction has been applied to all of the value for the average availability of total fat consumed. Digestion experiments with the basal ration alone as the only source of fat have been reported in connection with the animal-fat experiments, from which it was concluded that 9.89 per cent of the total weight of water-free feces occurs as metabolic products.[1] Subtracting the quantity represented by this percentage from the total ether extract of the feces, a value is obtained more nearly representing the weight of unutilized fat. The corrected value for the availability of olive oil then becomes 97.8 per cent.

The five subjects reported that they remained in normal physical condition during the experimental periods. In experiment No. 185, in which 80 grams of olive oil was eaten per day, the subject O. E. S. reported that the diet had a constipating effect. In experiments Nos. 243, 244, and 245, in which 82, 89, and 103 grams of olive oil were consumed, the subjects reported that the diet produced a pronounced laxative effect. However, in the experiments in which the laxative effect was noted, the olive oil was as completely assimilated as in the remaining experiments, and the tests as a whole yield additional evidence that, used in the usual ways for cooking and on the table, olive oil is a wholesome, valuable food.

COTTONSEED OIL.

Refined cottonseed oil is a common food product used as such in large quantities for culinary and table purposes, and also in the manufacture of hardened fats and other commercial fats designed for use in cookery.

Very few results have been found on record which concern the digestibility of cottonseed oil by the human organism, though animal feeding experiments have been rather common. Moore [2] has reported experiments intended to compare the digestibilities of several of the more common vegetable fats, concluding that all vegetable fats are equally well digested.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 20.

[2] Loc. cit.

The experiments made at this time concern only the actual percentage of fat available to the body, though it might be possible at the same time to notice approximately how much of the oil can be used without producing a laxative effect or other physiological disturbances. Six subjects assisted in the work, and the same methods were used which hitherto have proved entirely satisfactory. The data describing the results of the 12 test periods are as follows:

Data of digestion experiments with cottonseed oil in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 139, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cottonseed oil	1,915.0	913.4	32.6	264.3	697.1	7.6
Wheat biscuit	722.0	65.0	76.5	10.8	558.1	11.6
Fruit	1,351.0	1,174.0	10.8	2.7	156.7	6.8
Sugar	66.0	....	....	....	66.0	....
Total food consumed	4,054.0	2,152.4	119.9	277.8	1,477.9	26.0
Feces	102.0	....	27.5	11.7	53.6	9.2
Amount utilized	....	....	92.4	266.1	1,424.3	16.8
Per cent utilized	....	....	77.0	95.8	96.4	64.6
Experiment No. 140, subject H. D. G.:						
Blancmange containing cottonseed oil	1,148.0	547.6	19.5	158.4	417.9	4.6
Wheat biscuit	598.0	53.8	63.4	9.0	462.2	9.6
Fruit	1,274.0	1,107.1	10.2	2.5	147.8	6.4
Sugar	96.0	....	....	....	96.0	....
Total food consumed	3,116.0	1,708.5	93.1	169.9	1,123.9	20.6
Feces	100.5	....	26.7	10.4	53.3	10.1
Amount utilized	....	....	66.4	159.5	1,070.6	10.5
Per cent utilized	....	....	71.3	93.9	95.3	51.0
Experiment No. 141, subject R. L. S.:						
Blancmange containing cottonseed oil	1,495.0	713.1	25.4	206.3	544.2	6.0
Wheat biscuit	444.0	40.0	47.1	6.6	343.2	7.1
Fruit	1,246.0	1,082.8	10.0	2.5	144.5	6.2
Sugar	119.0	....	....	....	119.0	....
Total food consumed	3,304.0	1,835.9	82.5	215.4	1,150.9	19.3
Feces	87.0	....	28.0	18.1	31.3	9.6
Amount utilized	....	....	54.5	197.3	1,119.6	9.7
Per cent utilized	....	....	66.1	91.6	97.3	50.3
Experiment No. 142, subject R. F. T:						
Blancmange containing cottonseed oil	2,099.0	1,001.2	35.7	289.7	764.0	8.4
Wheat biscuit	110.0	9.9	11.7	1.6	85.0	1.8
Fruit	1,304.0	1,133.2	10.4	2.6	151.3	6.5
Sugar	85.0	....	....	....	85.0	....
Total food consumed	3,598.0	2,144.3	57.8	293.9	1,085.3	16.7
Feces	72.5	....	16.9	12.3	37.0	6.3
Amount utilized	....	....	40.9	281.6	1,048.3	10.4
Per cent utilized	....	....	70.8	95.8	96.6	62.3
Experiment No. 143, subject D. G. G.:						
Blancmange containing cottonseed oil	1,632.0	768.8	32.2	220.8	603.2	7.0
Wheat biscuit	913.0	82.2	96.8	13.7	705.7	14.6
Fruit	957.0	831.6	7.7	1.9	111.0	4.8
Sugar	163.0	....	....	....	163.0	....
Total food consumed	3,665.0	1,682.6	136.7	236.4	1,582.9	26.4
Feces	131.3	....	32.2	11.5	76.5	11.1
Amount utilized	....	....	104.5	224.9	1,506.4	15.3
Per cent utilized	....	....	76.4	95.1	95.2	58.0

Data of digestion experiments with cottonseed oil in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 144, subject H. D. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cottonseed oil	1,241.0	584.6	24.5	167.9	458.7	5.3
Wheat biscuit	775.0	69.8	82.1	11.6	599.1	12.4
Fruit	1,118.0	971.5	9.0	2.2	129.7	5.6
Sugar	178.0				178.0	
Total food consumed	3,312.0	1,625.9	115.6	181.7	1,365.5	23.3
Feces	121.5		37.8	11.4	60.4	11.9
Amount utilized			77.8	170.3	1,305.1	11.4
Per cent			67.3	93.7	95.6	48.9
Experiment No. 145, subject R. L. S.:						
Blancmange containing cottonseed oil	1,497.0	705.3	29.5	202.5	553.3	6.4
Wheat biscuit	359.0	32.3	38.1	5.4	277.5	5.7
Fruit	1,266.0	1,100.2	10.1	2.5	146.9	6.3
Sugar	76.0				76.0	
Total food consumed	3,198.0	1,837.8	77.7	210.4	1,053.7	18.4
Feces	91.9		25.7	14.0	43.5	8.7
Amount utilized			52.0	196.4	1,010.2	9.7
Per cent utilized			66.9	93.3	95.9	52.7
Experiment No. 146, subject R. F. T.:						
Blancmange containing cottonseed oil	2,112.0	995.0	41.6	285.7	780.6	9.1
Wheat biscuit	114.0	10.3	12.1	1.7	88.1	1.8
Fruit	1,178.0	1,023.7	9.4	2.4	136.6	5.9
Sugar	102.0				102.0	
Total food consumed	3,506.0	2,029.0	63.1	289.8	1,107.3	16.8
Feces	50.8		11.0	9.1	26.8	3.9
Amount utilized			52.1	280.7	1,080.5	12.9
Per cent utilized			82.6	96.9	97.6	76.8
Experiment No. 246, subject H. F. B.:						
Blancmange containing cottonseed oil	2,602.0	1,082.5	47.5	359.3	1,097.1	15.6
Wheat biscuit	721.0	64.9	76.4	10.8	557.3	11.6
Fruit	1,750.0	1,520.8	14.0	3.5	203.0	8.7
Sugar	209.0				209.0	
Total food consumed	5,282.0	2,668.2	137.9	373.6	2,066.4	35.9
Feces	165.0		40.5	21.2	89.4	13.9
Amount utilized			97.4	352.4	1,977.0	22.0
Per cent utilized			70.6	94.3	95.7	61.3
Experiment No. 247, subject D. G. G.:						
Blancmange containing cottonseed oil	2,162.0	899.3	39.5	298.6	911.6	13.0
Wheat biscuit	317.0	28.5	33.6	4.8	245.0	5.1
Fruit	1,657.0	1,439.9	13.3	3.3	192.2	8.3
Sugar	169.0				169.0	
Total food consumed	4,305.0	2,367.7	86.4	306.7	1,517.8	26.4
Feces	111.0		52.8	11.0	38.8	8.4
Amount utilized			33.6	295.7	1,479.0	18.0
Per cent utilized			38.9	96.4	97.4	68.2
Experiment No. 248, subject R. L. S.:						
Blancmange containing cottonseed oil	2,005.0	834.1	36.6	276.9	845.4	12.0
Wheat biscuit	366.0	32.9	38.8	5.5	282.9	5.9
Fruit	1,229.0	1,068.0	9.8	2.5	142.6	6.1
Sugar	89.0				89.0	
Total food consumed	3,689.0	1,935.0	85.2	284.9	1,359.9	24.0
Feces	78.0		37.0	13.4	20.2	7.4
Amount utilized			48.2	271.5	1,339.7	16.6
Per cent utilized			56.6	95.3	98.5	69.2
Experiment No. 249, subject O. E. S.:						
Blancmange containing cottonseed oil	2,725.0	1,133.6	49.7	376.3	1,149.0	16.4
Wheat biscuit	433.0	39.0	45.9	6.5	334.7	6.9
Fruit	1,745.0	1,516.4	14.0	3.5	202.4	8.7
Sugar	181.0				181.0	
Total food consumed	5,084.0	2,689.0	109.6	386.3	1,867.1	32.0
Feces	106.0		34.2	12.1	51.6	8.1
Amount utilized			75.4	374.2	1,815.5	23.9
Per cent utilized			68.8	96.9	97.2	74.7
Average food consumed per subject per day	1,280.9	685.5	32.4	89.6	465.5	7.9

Summary of digestion experiments with cottonseed oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
139	D. G. G	77.0	95.8	96.4	64.6
140	H. D. G	71.3	93.9	95.3	51.0
141	R. L. S	66.1	91.6	97.3	50.3
142	R. F. T	70.8	95.8	96.6	62.3
143	D. G. G	76.4	95.1	95.2	58.0
144	H. D. G	67.3	93.7	95.6	48.9
145	R. L. S	66.9	93.3	95.9	52.7
146	R. F. T	82.6	96.9	97.6	76.8
246	H. F. B	70.6	94.3	95.7	61.3
247	D. G. G	38.9	96.4	97.4	68.2
248	R. L. S	56.6	95.3	98.5	69.2
249	O. E. S	68.8	96.9	97.2	74.7
	Average	67.8	94.9	96.6	61.5

The average coefficient of digestibility of the fat, of which over 96.3 per cent was cottonseed oil, was 94.9 per cent, while 67.8 per cent of the protein and 96.6 per cent of the carbohydrates were retained in the body. Making allowance for that portion of the ether extract designated metabolic products the actual availability of the cottonseed oil becomes 97.6 per cent. In 9 of the 12 experiments the subjects reported that the feces were of a normal consistency. In experiments Nos. 142 and 247, in which 94 and 98 grams of cottonseed oil was consumed, the subjects reported that the feces were softer than normal. In experiment No. 249, however, in which 125 grams of cottonseed oil was eaten daily, the subject reported the diet as being constipating. Accordingly, it would seem that cottonseed oil does not act as a laxative when eaten in amounts not exceeding 125 grams daily. In view of the fact that 86 grams of cottonseed oil was eaten by each subject daily without digestive disturbances of any kind it is reasonable to conclude that cottonseed oil may be used freely for culinary or table purposes.

PEANUT OIL.

The total quantity of peanuts eaten is very large and it follows that the amount of oil eaten as an integral part of the nuts is also large. The partially separated oil as it occurs in peanut butter is easily recognized, and this, too, is eaten in quantity. The expressed oil has long been known for culinary and table purposes, and its use has increased in the United States as the methods of manufacture have improved.

The only investigations of the food value of peanut oil of which accounts have been found in the literature are those of Moore[1] on the relative digestibility of various edible fats and oils of vegetable origin, which showed that peanut oil was 86 per cent digested by guinea pigs.

Part of the oil used in the experiments reported in this bulletin was prepared by the Bureau of Chemistry of the United States Department of Agriculture, and the remainder was purchased in the open market. That obtained from the Bureau of Chemistry was manufactured in its laboratories, and being freshly made was judged to be of most excellent quality. The commercial samples were much older, but were considered excellent in odor, flavor, and color. There was no apparent difference in the flavor of the two samples, which would seem to indicate that peanut oil which has been carefully handled has good keeping qualities, and as no noteworthy differences in properties appeared in the digestion experiments no further reference will be made to the source of the oil used.

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[1] Loc. cit.

Four different subjects assisted in the study of this fat, and the usual uniform and standardized conditions of conducting the work were maintained throughout the experiments. The results of the five tests are as follows:

Data of digestion experiments with peanut oil in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 30, subject J. N. F.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing peanut oil	1,918.0	1,037.0	47.8	340.6	481.2	11.4
Wheat biscuit	241.0	21.7	25.5	3.6	186.3	3.9
Fruit	1,002.0	847.7	4.0	5.0	142.3	3.0
Sugar	52.0	....	....	....	52.0	....
Total food consumed	3,213.0	1,906.4	77.3	349.2	861.8	18.3
Feces	68.0	....	23.8	8.8	27.2	8.2
Amount utilized	....	....	53.5	340.4	834.6	10.1
Per cent utilized	....	....	69.2	97.5	96.8	55.2
Experiment No. 31, subject W. E. L.:						
Blancmange containing peanut oil	1,476.0	797.0	36.9	262.5	370.9	8.7
Wheat biscuit	26.0	2.3	2.8	0.4	20.1	0.4
Fruit	1,000.0	846.0	4.0	5.0	142.0	3.0
Sugar	143.0	....	....	....	143.0	....
Total food consumed	2,645.0	1,645.3	43.7	267.9	676.0	12.1
Feces	32.0	....	11.4	6.4	10.5	3.7
Amount utilized	....	....	32.3	261.5	665.5	8.4
Per cent utilized	....	....	73.9	97.6	98.4	69.4
Experiment No. 32, subject W. A. D.:						
Blancmange containing peanut oil	1,883.0	1,022.4	47.2	332.6	469.7	11.1
Wheat biscuit	442.0	39.8	46.8	6.6	341.7	7.1
Fruit	819.0	692.9	3.3	4.1	116.3	2.4
Sugar	68.0	....	....	....	68.0	....
Total food consumed	3,212.0	1,755.1	97.3	343.3	995.7	20.6
Feces	78.0	....	18.1	13.4	36.7	9.8
Amount utilized	....	....	79.2	329.9	959.0	10.8
Per cent utilized	....	....	81.4	96.1	96.3	52.4
Experiment No. 36, subject J. N. F.:						
Blancmange containing peanut oil	1,787.0	1,059.3	43.4	275.8	397.2	11.3
Wheat biscuit	224.0	20.2	23.7	3.4	173.1	3.6
Fruit	1,521.0	1,321.8	12.2	3.0	176.4	7.6
Sugar	40.0	....	....	....	40.0	....
Total food consumed	3,572.0	2,401.3	79.3	282.2	786.7	22.5
Feces	78.0	....	18.1	17.7	31.5	10.7
Amount utilized	....	....	61.2	264.5	755.2	11.8
Per cent utilized	....	....	77.2	93.7	96.0	52.4
Experiment No. 37, subject J. V. C.:						
Blancmange containing peanut oil	1,704.0	1,010.7	41.6	262.9	377.8	11.0
Wheat biscuit	291.0	26.2	30.8	4.4	224.9	4.7
Fruit	1,442.0	1,253.1	11.5	2.9	167.3	7.2
Sugar	231.0	....	....	....	231.0	....
Total food consumed	3,668.0	2,290.0	83.9	270.2	1,001.0	22.9
Feces	78.0	....	20.0	12.7	32.6	12.7
Amount utilized	....	....	63.9	257.5	968.4	10.2
Per cent utilized	....	....	76.2	95.3	96.7	44.5
Average food consumed per subject per day.	1,087.3	666.5	25.4	100.9	288.1	6.4

Summary of digestion experiments with peanut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
30	J. N. F	69.2	97.5	96.8	55.2
31	W. E. L.	73.9	97.6	98.4	69.4
32	W. A. D	81.4	96.1	96.3	52.4
36	J. N. F	77.2	93.7	96.0	52.4
37	J. V. C	76.2	95.3	96.7	44.5
	Average	75.6	96.0	96.8	54.8

Approximately 98 grams of peanut oil or 97 per cent of the total amount of fat in this diet was eaten per subject per day, and as the coefficient of availability, 96 per cent, implies, the fat was very completely assimilated. This value is increased somewhat by correcting for metabolic products, from which it is calculated that peanut oil is 98.3 per cent digested.

The protein and carbohydrate in the ration were also well utilized, for by way of comparison it has been found that in the total food of the ordinary mixed diet 92 per cent of the protein, 95 per cent of the fat, and 97 per cent of the carbohydrate are retained by the body.[1]

As the subjects reported no unusual effects as a result of eating this diet, and as no laxative effect was observed, it is apparent that peanut oil of good quality is a useful food, which can be eaten in the same quantities and can be as thoroughly digested as those fats and oils at present most commonly used in the diet.

COCONUT OIL.

Coconut oil is obtained from the fruit of the palm *Cocos nucifera*. In recent years it has become rather widely known and is assuming considerable importance as a culinary and table fat. It is used in the commercial baking trade more commonly than it is for household purposes and to some extent in the preparation of butter substitutes.

The digestibility of coconut oil has not been extensively studied. Bourot and Jean[2] carried on a series of experiments with subjects who received foods prepared first with natural butter and then with coconut butter. They concluded that the vegetable product was somewhat more thoroughly assimilated than was butter, the former being 98 per cent and the latter 96 per cent digested.

In a series of tests of 28 days' duration, divided into a fore period of 7 days, a 14-day experimental period, and an after period of 7 days, Von Gerlach[3] found that purified coconut oil, called "sanella," and true butter were both 97 per cent digested.

Lührig[4] reports a similar study in which different amounts of so-called coconut butter designed for use as a butter substitute were eaten in a simple mixed diet. In one of the tests 136 grams of the fat was consumed daily for three days, and in the second 90 grams per day for the same length of time. In the first test the fat was 97 per cent available and in the second, 96 per cent was assimilated.

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[1] Connecticut Storr's Sta. Rpt. 1901, p. 245.

[2] Compt. Rend. Acad. Sci. [Paris], 123 (1896), No. 16, pp. 587–590.

[3] Ztschr. Phys. u. Diätet. Ther., 12 (1908–9), No. 2, pp. 102–110.

[4] Ztschr. Untersuch. Nahr. u. Genussmtl., 2 (1899), No. 8, pp. 622–632.

Seven experiments are reported in this paper to compare the digestibility of coconut oil with that of other edible fats, and four experienced subjects assisted in the work. Under conditions customary in these tests, the data have been collected and are summarized in the following tables:

Data of digestion experiments with coconut oil in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 175, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing coconut oil	1,057.0	498.6	19.8	108.9	424.1	5.6
Wheat biscuit	656.0	59.1	69.5	9.8	507.1	10.5
Fruit	660.0	573.5	5.3	1.3	76.6	3.3
Sugar	125.0				125.0	
Total food consumed	2,498.0	1,131.2	94.6	120.0	1,132.8	19.4
Feces	98.0		28.4	8.5	52.4	8.7
Amount utilized			66.2	111.5	1,080.4	10.7
Per cent utilized			70.0	92.9	95.4	55.2
Experiment No. 176, subject R. L. S.:						
Blancmange containing coconut oil	1,518.0	716.0	28.5	156.4	609.1	8.0
Wheat biscuit	293.0	26.4	31.0	4.4	226.5	4.7
Fruit	1,335.0	1,160.1	10.7	2.7	154.8	6.7
Sugar	127.0				127.0	
Total food consumed	3,273.0	1,902.5	70.2	163.5	1,117.4	19.4
Feces	79.0		26.3	13.5	30.5	8.7
Amount utilized			43.9	150.0	1,086.9	10.7
Per cent utilized			62.5	91.7	97.3	55.2
Experiment No. 177, subject O. E. S.:						
Blancmange containing coconut oil	1,741.0	821.2	32.7	179.3	698.6	9.2
Wheat biscuit	98.0	8.8	10.4	1.5	75.7	1.6
Fruit	1,398.0	1,214.9	11.2	2.8	162.1	7.0
Sugar	37.0				37.0	
Total food consumed	3,274.0	2,044.9	54.3	183.6	973.4	17.8
Feces	77.0		25.0	8.3	36.6	7.1
Amount utilized			29.3	175.3	936.8	10.7
Per cent utilized			54.0	95.5	96.2	60.1
Experiment No. 178, subject R. F. T.:						
Blancmange containing coconut oil	1,460.0	688.7	27.4	150.4	585.8	7.7
Wheat biscuit	74.0	6.7	7.8	1.1	57.2	1.2
Fruit	1,317.0	1,144.5	10.5	2.6	152.8	6.6
Sugar	139.0				139.0	
Total food consumed	2,990.0	1,839.9	45.7	154.1	934.8	15.5
Feces	52.0		13.8	7.7	24.8	5.7
Amount utilized			31.9	146.4	910.0	9.8
Per cent utilized			69.8	95.0	97.3	63.2
Experiment No. 199, subject D. G. G.:						
Blancmange containing coconut oil	863.0	398.9	16.7	90.9	350.2	6.3
Wheat biscuit	525.0	47.2	55.7	7.9	405.8	8.4
Fruit	396.0	344.1	3.2	0.8	45.9	2.0
Sugar	162.0				162.0	
Total food consumed	1,946.0	790.2	75.6	99.6	963.9	16.7
Feces	94.0		28.8	11.9	44.8	8.5
Amount utilized			46.8	87.7	919.1	8.2
Per cent utilized			61.9	88.1	95.4	49.1

Data of digestion experiments with coconut oil in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 200, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing coconut oil	1,537.0	710.4	29.8	161.9	623.7	11.2
Wheat biscuit	366.0	32.9	38.8	5.5	282.9	5.9
Fruit	401.0	348.5	3.2	0.8	46.5	2.0
Sugar	155.0				155.0	
Total food consumed	2,459.0	1,091.8	71.8	168.2	1,108.1	19.1
Feces	103.0		33.4	15.8	42.2	11.6
Amount utilized			38.4	152.4	1,065.9	7.5
Per cent utilized			53.5	90.6	96.2	39.3
Experiment No. 201, subject O. E. S.:						
Blancmange containing coconut oil	1,841.0	850.9	35.7	193.9	747.1	13.4
Wheat biscuit	186.0	16.7	19.7	2.8	143.8	3.0
Fruit	1,713.0	1,488.6	13.7	3.4	198.7	8.6
Sugar	166.0				166.0	
Total food consumed	3,906.0	2,356.2	69.1	200.1	1,255.6	25.0
Feces	94.0		29.7	11.8	43.1	9.4
Amount utilized			39.4	188.3	1,212.5	15.6
Per cent utilized			57.0	94.1	96.6	62.4
Experiment No. 202, subject R. F. T.:						
Blancmange containing coconut oil	1,247.0	576.4	24.2	131.3	506.0	9.1
Wheat biscuit	62.0	5.6	6.6	0.9	47.9	1.0
Fruit	1,412.0	1,227.0	11.3	2.8	163.8	7.1
Sugar	112.0				112.0	
Total food consumed	2,833.0	1,809.0	42.1	135.0	829.7	17.2
Feces	37.0		10.5	6.1	16.2	4.2
Amount utilized			31.6	128.9	813.5	13.0
Per cent utilized			75.1	95.5	98.0	75.6
Experiment No. 222, subject D. G. G.:						
Blancmange containing coconut oil	1,625.0	744.2	30.5	238.7	600.2	11.4
Wheat biscuit	490.0	44.1	51.9	7.4	378.8	7.8
Fruit	965.0	838.6	7.7	1.9	112.0	4.8
Sugar	210.0				210.0	
Total food consumed	3,290.0	1,626.9	90.1	248.0	1,301.0	24.0
Feces	84.0		25.8	9.5	41.3	7.4
Amount utilized			64.3	238.5	1,259.7	16.6
Per cent utilized			71.4	96.2	96.8	69.2
Experiment No. 223, subject R. L. S.:						
Blancmange containing coconut oil	1,847.0	845.9	34.7	271.3	682.2	12.9
Wheat biscuit	290.0	26.1	30.7	4.4	224.2	4.6
Fruit	1,065.0	925.5	8.5	2.1	123.6	5.3
Sugar	96.0				96.0	
Total food consumed	3,298.0	1,797.5	73.9	277.8	1,126.0	22.8
Feces	93.0		29.0	17.5	36.7	9.8
Amount utilized			44.9	260.3	1,089.3	13.0
Per cent utilized			60.8	93.7	96.7	57.0
Experiment No. 224, subject O. E. S.:						
Blancmange containing coconut oil	2,678.0	1,226.5	50.2	393.4	989.1	18.8
Wheat biscuit	263.0	23.7	27.9	3.9	203.3	4.2
Fruit	1,449.0	1,259.2	11.6	2.9	168.1	7.2
Sugar	196.0				196.0	
Total food consumed	4,586.0	2,509.4	89.7	400.2	1,556.5	30.2
Feces	96.0		26.9	14.9	46.6	7.6
Amount utilized			62.8	385.3	1,509.9	22.6
Per cent utilized			70.0	96.3	97.0	74.8
Experiment No. 225, subject R. F. T.:						
Blancmange containing coconut oil	1,696.0	776.8	31.8	249.1	626.4	11.9
Wheat biscuit	221.0	19.9	23.4	3.3	170.8	3.6
Fruit	1,317.0	1,144.5	10.5	2.6	152.8	6.6
Sugar	130.0				130.0	
Total food consumed	3,364.0	1,941.2	65.7	255.0	1,080.0	22.1
Feces	78.0		20.8	18.7	29.5	9.0
Amount utilized			44.9	236.3	1,050.5	13.1
Per cent utilized			68.3	92.7	97.3	59.3
Average food consumed per subject per day	1,047.7	578.9	23.4	66.8	371.7	6.9

Summary of digestion experiments with coconut oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
175	D. G. G	70.0	92.9	95.4	55.2
176	R. L. S	62.5	91.7	97.3	55.2
177	O. E. S	54.0	95.5	96.2	60.1
178	R. F. T	69.8	95.0	97.3	63.2
199	D. G. G	61.9	88.1	95.4	49.1
200	R. L. S	53.5	90.6	96.2	39.3
201	O. E. S	57.0	94.1	96.6	62.4
202	R. F. T	75.1	95.5	98.0	75.6
222	D. G. G	71.4	96.2	96.8	69.2
223	R. L. S	60.8	93.7	96.7	57.0
224	O. E. S	70.0	96.3	97.0	74.8
225	R. F. T	68.3	92.7	97.3	59.3
	Average	64.5	93.5	96.7	60.0

On an average 64.6 grams of coconut oil was eaten daily and was well digested by the four subjects in these experiments, the average coefficient of digestibility being 93.5 per cent. The coefficient of availability is increased to 97.9 per cent by correcting for the metabolic products occurring in conjunction with the unutilized fat in the ether extract of the feces. In experiment No. 224, with subject O. E. S., a relatively large amount of the fat, 131 grams per day, was even more completely assimilated and, as evidenced by the report, produced no abnormal alimentary symptoms. In fact, no one of the subjects reported any laxative condition.

The protein and carbohydrates were 64.5 per cent and 96.7 per cent available to the body, values which compare favorably with the thoroughness of digestion of these constituents usually found in similar tests. It may be reasonably concluded on the basis of these results that coconut oil is suited to serve satisfactorily for food purposes.

SESAME OIL.

The seeds of the sesame plant (*Sesamum indicum*) yield when subjected to pressure an oil very similar in properties to cottonseed oil. Sesame oil is not produced in the United States for culinary purposes, although it is well known elsewhere and is imported to some extent for use by those who have become accustomed to its use in other countries.

Although tests of its digestibility have not been found on record, it is evident from a knowledge of oriental food habits and diets that sesame oil is well known as a useful food in the far eastern countries. The experiments herein reported were undertaken in order that the comparative results obtained with the vegetable fats might be as comprehensive as possible. The same methods were employed in these tests as with the other fats, and four subjects took part in the work. The experimental data are recorded below:

Data of digestion experiments with sesame oil in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Experiment No. 325, subject O. E. S.:						
Blancmange containing sesame oil	2,052.0	1,000.1	44.9	245.4	752.1	9.5
Wheat biscuit	394.0	35.4	41.8	5.9	304.6	6.3
Fruit	1,376.0	1,195.7	11.0	2.8	159.6	6.9
Sugar	141.0				141.0	
Total food consumed	3,963.0	2,231.2	97.7	254.1	1,357.3	22.7
Feces	88.0		30.9	12.0	36.4	8.7
Amount utilized			66.8	242.1	1,320.9	14.0
Per cent untilized			68.4	95.3	97.3	61.7
Experiment No. 330, subject H. F. B.:						
Blancmange containing sesame oil	2,146.0	975.6	44.2	299.1	818.3	8.8
Wheat biscuit	435.0	39.1	46.1	6.5	336.3	7.0
Fruit	1,046.0	909.0	8.4	2.1	121.3	5.2
Sugar	224.0				224.0	
Total food consumed	3,851.0	1,923.7	98.7	307.7	1,499.9	21.0
Feces	131.0		43.9	21.6	53.2	12.3
Amount utilized			54.8	286.1	1,446.7	8.7
Per cent utilized			55.5	93.0	96.5	41.4
Experiment No. 331, subject D. G. G.:						
Blancmange containing sesame oil	1,409.0	640.5	29.0	196.4	537.3	5.8
Wheat biscuit	594.0	53.4	63.0	8.9	459.2	9.5
Fruit	489.0	424.9	3.9	1.0	56.7	2.5
Sugar	136.0				136.0	
Total food consumed	2,628.0	1,118.8	95.9	206.3	1,189.2	17.8
Feces	134.0		41.6	16.2	65.7	10.5
Amount utilized			54.3	190.1	1,123.5	7.3
Per cent utilized			56.6	92.1	94.5	41.0
Experiment No. 332, subject R. L. S.:						
Blancmange containing sesame oil	2,028.0	921.9	41.8	282.7	773.3	8.3
Wheat biscuit	382.0	34.4	40.5	5.7	295.3	6.1
Fruit	601.0	522.3	4.8	1.2	69.7	3.0
Sugar	122.0				122.0	
Total food consumed	3,133.0	1,478.6	87.1	289.6	1,260.3	17.4
Feces	95.0		32.7	16.5	36.5	9.3
Amount utilized			54.4	273.1	1,223.8	8.1
Per cent utilized			62.5	94.3	97.1	46.6
Experiment No. 333, subject O. E. S.:						
Blancmange containing sesame oil	2,291.0	1,041.5	47.2	319.4	873.5	9.4
Wheat biscuit	411.0	37.0	43.6	6.1	317.7	6.6
Fruit	1,274.0	1,107.1	10.2	2.5	147.8	6.4
Sugar	320.0				320.0	
Total food consumed	4,296.0	2,185.6	101.0	328.0	1,659.0	22.4
Feces	117.0		36.6	18.2	51.1	11.1
Amount utilized			64.4	309.8	1,607.9	11.3
Per cent utilized			63.8	94.5	96.9	50.4
Average food consumed per subject per day	1,191.4	595.9	32.0	92.4	464.4	6.7

Summary of digestion experiments with sesame oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
325	O. E. S.	68.4	95.3	97.3	61.7
330	H. F. B.	55.5	93.0	96.5	41.4
331	D. G. G.	56.6	92.1	94.5	41.0
332	R. L. S.	62.5	94.3	97.1	46.6
333	O. E. S.	63.8	94.5	96.9	50.4
	Average	61.4	93.8	96.5	48.2

The results of these tests indicate that sesame oil compares favorably with the preceding vegetable fats as regards thoroughness of digestion. Of the total fat in the diet, 93.8 per cent was available while 61.4 and 96.5 per cent of the protein and carbohydrates were utilized by the body. The revised value for the digestibility of sesame oil alone, allowing for metabolic products, is 98 per cent.

The amount of sesame oil eaten per subject daily was 90 grams, and in one case, experiment No. 333 with subject O. E. S., 106 grams of the fat was consumed daily without apparent physiological aversion, and when eaten in amounts not exceeding 106 grams daily it apparently produces no laxative effect. Sesame oil, therefore, may be considered a useful food.

COCOA BUTTER.

Cocoa butter is obtained as a by-product of the manufacture of cocoa from the cocoa bean, the fruit of *Theobroma cacao*. The product is a hard, yellowish fat of the odor of cocoa and has an agreeable taste and rather low melting point. Compared with other vegetable fats cocoa butter is relatively expensive and for this reason no doubt it is little used as such in the preparation of food products, although large quantities of cocoa butter are eaten as an intimate constituent of chocolate.

As no noteworthy records of physiological tests of this fat have been found in the review of the literature it is hoped that the results of these experiments may be of special value. The fat, already used in quantity in the making of confectionery, may assume importance in other ways when it is possible to have a definite opinion regarding the dietetic value of chocolate (retaining the cocoa fat) and cocoa (from which fat has been removed). The experimental data are recorded in the following table:

Data of digestion experiments with cocoa butter in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 167, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cocoa butter	1,315.0	594.3	23.0	180.8	511.1	5.8
Wheat biscuit	497.0	44.7	52.7	7.4	384.2	8.0
Fruit	611.0	531.0	4.9	1.2	70.9	3.0
Sugar	191.0	....	....	....	191.0	....
Total food consumed	2,614.0	1,170.0	80.6	189.4	1,157.2	16.8
Feces	112.0	....	30.2	13.3	57.8	10.7
Amount utilized	....	....	50.4	176.1	1,099.4	6.1
Per cent utilized	....	....	62.5	93.0	95.0	36.3
Experiment No. 168, subject R. L. S.:						
Blancmange containing cocoa butter	1,310.0	592.0	22.9	180.1	509.2	5.8
Wheat biscuit	291.0	26.2	30.8	4.4	224.9	4.7
Fruit	1,232.0	1,070.6	9.8	2.5	142.9	6.2
Sugar	63.0	....	....	....	63.0	....
Total food consumed	2,896.0	1,688.8	63.5	187.0	940.0	16.7
Feces	84.0	....	25.6	19.2	30.5	8.7
Amount utilized	....	....	37.9	167.8	909.5	8.0
Per cent utilized	....	....	59.7	89.7	96.8	47.9

Data of digestion experiments with cocoa butter in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 169, subject O. E. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cocoa butter	1,465.0	662.0	25.6	201.4	569.5	6.5
Wheat biscuit	83.0	7.5	8.8	1.2	64.2	1.3
Fruit	1,392.0	1,209.6	11.1	2.8	161.5	7.0
Sugar	68.0				68.0	
Total food consumed	3,008.0	1,879.1	45.5	205.4	863.2	14.8
Feces	68.0		18.9	16.3	26.2	6.6
Amount utilized			26.6	189.1	837.0	8.2
Per cent utilized			58.5	92.1	97.0	55.4
Experiment No. 170, subject R. F. T.:						
Blancmange containing cocoa butter	1,391.0	628.6	24.3	191.3	540.7	6.1
Wheat biscuit	71.0	6.4	7.5	1.1	54.9	1.1
Fruit	1,459.0	1,267.9	11.7	2.9	169.2	7.3
Sugar	141.0				141.0	
Total food consumed	3,062.0	1,902.9	43.5	195.3	905.8	14.5
Feces	61.0		13.8	11.4	29.8	6.0
Amount utilized			29.7	183.9	876.0	8.5
Per cent utilized			68.3	94.2	96.7	58.6
Experiment No. 191, subject D. G. G.:						
Blancmange containing cocoa butter	582.0	261.7	10.4	80.6	225.9	3.4
Wheat biscuit	509.0	45.8	54.0	7.6	393.5	8.1
Fruit	432.0	375.4	3.4	0.9	50.1	2.2
Sugar	189.0				189.0	
Total food consumed	1,712.0	682.9	67.8	89.1	858.5	13.7
Feces	69.0		21.6	9.4	31.2	6.8
Amount utilized			46.2	79.7	827.3	6.9
Per cent utilized			68.1	89.5	96.4	50.4
Experiment No. 192, subject R. L. S.:						
Blancmange containing cocoa butter	812.0	365.2	14.5	112.4	315.1	4.8
Wheat biscuit	564.0	50.7	59.8	8.5	436.0	9.0
Fruit	1,372.0	1,192.3	11.0	2.7	159.1	6.9
Sugar	123.0				123.0	
Total food consumed	2,871.0	1,608.2	85.3	123.6	1,033.2	20.7
Feces	114.0		31.7	25.8	41.5	15.0
Amount utilized			53.6	97.8	991.7	5.7
Per cent utilized			62.8	79.1	96.0	27.5
Experiment No. 193, subject O. E. S.:						
Blancmange containing cocoa butter	1,230.0	553.1	22.0	170.2	477.3	7.4
Wheat biscuit	127.0	11.4	13.5	1.9	98.2	2.0
Fruit	1,482.0	1,287.9	11.8	3.0	171.9	7.4
Sugar	198.0				198.0	
Total food consumed	3,037.0	1,852.4	47.3	175.1	945.4	16.8
Feces	40.0		11.9	7.9	15.9	4.3
Amount utilized			35.4	167.2	929.5	12.5
Per cent utilized			74.8	95.5	98.3	74.4
Experiment No. 194, subject R. F. T.:						
Blancmange containing cocoa butter	807.0	362.9	14.4	111.7	313.2	4.8
Wheat biscuit	93.0	8.4	9.8	1.4	71.9	1.5
Fruit	1,262.0	1,096.7	10.1	2.5	146.4	6.3
Sugar	163.0				163.0	
Total food consumed	2,325.0	1,468.0	34.3	115.6	694.5	12.6
Feces	36.0		9.7	8.6	13.4	4.3
Amount utilized			24.6	107.0	681.1	8.3
Per cent utilized			71.7	92.6	98.1	65.9
Experiment No. 235, subject D. G. G.:						
Blancmange containing cocoa butter	1,571.0	702.4	29.0	246.2	582.3	11.1
Wheat biscuit	439.0	39.5	46.5	6.6	339.4	7.0
Fruit	337.0	292.8	2.7	0.7	39.1	1.7
Sugar	114.0				114.0	
Total food consumed	2,461.0	1,034.7	78.2	253.5	1,074.8	19.8
Feces	146.0		34.9	33.6	64.1	13.4
Amount utilized			43.3	219.9	1,010.7	6.4
Per cent utilized			55.4	86.7	94.0	32.3

Data of digestion experiments with cocoa butter in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 236, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cocoa butter	2,020.0	903.2	37.2	316.5	748.8	14.3
Wheat biscuit	433.0	39.0	45.9	6.5	334.7	6.9
Fruit	716.0	622.2	5.7	1.4	83.1	3.6
Sugar	84.0				84.0	
Total food consumed	3,253.0	1,564.4	88.8	324.4	1,250.6	24.8
Feces	129.0		33.5	32.9	49.5	13.1
Amount utilized			55.3	291.5	1,201.1	11.7
Per cent utilized			62.3	89.9	96.0	47.2
Experiment No. 237, subject O. E. S.:						
Blancmange containing cocoa butter	2,649.0	1,184.4	48.7	415.1	982.0	18.8
Wheat biscuit	463.0	41.7	49.1	6.9	357.9	7.4
Fruit	1,280.0	1,112.3	10.2	2.6	148.5	6.4
Sugar	228.0				228.0	
Total food consumed	4,620.0	2,338.4	108.0	424.6	1,716.4	32.6
Feces	195.0		37.7	72.6	70.2	14.5
Amount utilized			70.3	352.0	1,646.2	18.1
Per cent utilized			65.1	82.9	95.9	55.5
Average food consumed per subject per day	965.4	520.9	22.5	69.2	346.6	6.2

Summary of digestion experiments with cocoa butter in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
167	D. G. G	62.5	93.0	95.0	36.3
168	R. L. S	59.7	89.7	96.8	47.9
169	O. E. S	58.5	92.1	97.0	55 4
170	R. F. T	68.3	94.2	96.7	58.6
191	D. G. G	68.1	89.5	96.4	50.4
192	R. L. S	62.8	79.1	96.0	27.5
193	O. E. S	74.8	95.5	98.3	74.4
194	R. F. T	71.7	92 6	98.1	65.9
235	D. G. G	55.4	86.7	94.0	32.3
236	R. L. S	62.3	89.9	96.0	47.2
237	O. E. S	65.1	82.9	95.9	55.5
	Average	64.5	89.6	96.4	50.1

On an average the coefficient of digestibility of this fat was low, the corrected value being 94.9 per cent. It will be recalled that the food (blancmange) used as a vehicle for fat in such experiments as this is eaten ad libitum from a weighed amount, provided the amount being such that the subjects would naturally be inclined to eat a quantity which would supply in the neighborhood of 100 grams of fat per day. The fat-carrying blancmange was evidently not relished in this test as it was in the others here reported, for the amount eaten was only enough to supply 51 grams of cocoa fat per man per day during the first eight experiments. This quantity did not cause any decided digestive disturbance so far as was noted. The subjects reported a "loss of appetite," but in all other respects considered that their physical condition had been normal. In later tests, experiments Nos. 235 to 237, the subjects were urged to eat more of the blancmange containing the cocoa butter. As a result of eating the larger quantities, an average of 109 grams per day (82 grams for D. G. G., 106 grams for R. L. S., and 138 grams for O. E. S.), undesirable physiological derangements were experienced. The effects were so pronounced that subject D. G. G. discontinued the diet at the end of the seventh meal, but subjects R. L. S. and O. E. S. completed the full nine-meal period. "Loss of appetite," "headache," "loss of ambition," "nausea," and "sleeplessness" were the conditions reported, which indicate that cocoa butter in quantity had an effect not noted of the other vegetable fats studied. Though the exact limit of tolerance has not been determined, to judge by the experiments made in this laboratory, the maximum amount of cocoa butter that can be consumed daily without decidedly unpleasant effects lies between 51 grams and 109 grams.

The digestibility of the carbohydrate, 96.4 per cent, and of the protein, 64.5 per cent, agrees fairly closely with the average availability of these constituents, and would seem to be uninfluenced by the digestibility of the fat.

It will be noted on reference to the table that the feces contained comparatively large quantities of fat during the last three experiments. In experiment No. 237 as much as 37 per cent of the weight of the air-dried feces was fat, and an odor suggesting that of cocoa butter could be clearly detected. In view of the unsatisfactory utilization of this fat and the accompanying physiological disturbances, the continued daily use of cocoa butter in large amounts would appear questionable, and, as a matter of fact, it does not seem to be so used.

CONCLUSIONS.

(1) With allowance for metabolic products, the coefficients of digestibility have been found to be for olive oil, 97.8; for cottonseed oil, 97.8; for peanut oil, 98.3; for coconut oil, 97.9; for sesame oil, 98; and for cocoa butter, 94.9 per cent. These values indicate that the vegetable fats studied, with the exception of cocoa butter, have for all practical purposes the same digestibility and are utilized as completely as the animal fats.

(2) The melting points of these fats are considerably lower than body temperature (37° C.) and in accordance with the theory that fats of low melting points are more thoroughly digested than the harder fats, it has been found that the vegetable fats studied, with the exception of cocoa butter, are utilized practically completely by the body.

(3) The average amounts of fat eaten per subject daily were 73 grams of olive, 86 grams of cotton seed, 98 grams of peanut, 64 grams of coconut, and 90 grams of sesame oils. Moreover, as much as 103, 125, 113, 131, and 106 grams of these fats, respectively, were eaten

by one of the subjects for a 3-day period without any physiological disturbance. In the first eight experiments with cocoa butter, in which an average of only 51 grams of this fat was eaten daily, no abnormal conditions were noted and the apparent digestibility of fat was 90.7 per cent. In those experiments, however, in which 82 to 138 grams of cocoa butter were consumed daily and 86.5 per cent utilized, a decided laxative effect was noted. Accordingly, it may be concluded that the limit of tolerance is less for cocoa butter than for the other fats studied.

(4) The evidence collected in these experiments affords additional proof that the digestibility of protein and carbohydrate contained in the different fat diets was not materially affected by the nature of the fat or by the amount eaten.

(5) The total energy values (heats of combustion) of the material consumed on the average per man per day were 2,700 calories for olive oil, 2,955 calories for cottonseed oil, 2,290 calories for peanut oil, 2,305 calories for coconut oil, 2,975 calories for sesame oil, and 2,215 calories for cocoa butter. While no attention was given to the energy value of these diets, it is interesting to note that the amount of food consumed contained sufficient energy value except for those engaged in muscular activities. The percentage of energy actually available to the body was 93.9 for olive oil, 93.4 for cottonseed oil, 93.9 for peanut oil, 93.1 for coconut oil, 92.8 for sesame oil, and 91.9 for cocoa butter. These values imply, on comparison with the percentage of energy available from the ordinary mixed diet, which is 91 per cent,[1] that normal conditions existed during the digestion experiments and that protein, fat, and carbohydrates were as thoroughly digested as is usually the case.

(6) Judging from the results of the investigation as a whole, it is reasonable to conclude that olive, cottonseed, peanut, coconut, and sesame oils are very completely and readily available to the body and that they may, like the animal fats, be satisfactorily used for food purposes.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 136 (1903), p. 113.

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